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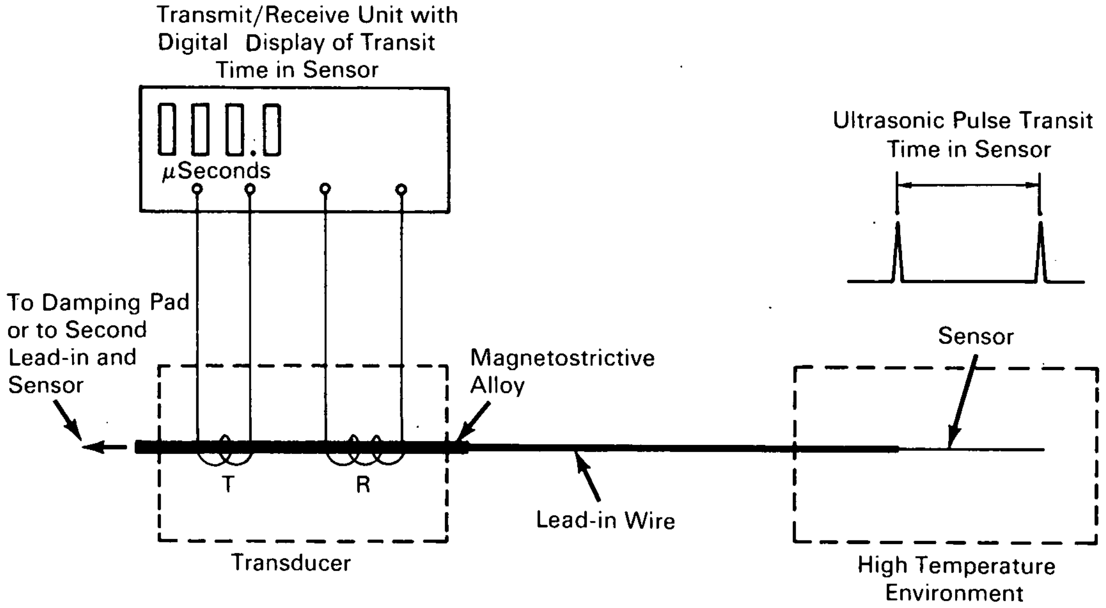
NASA TECH BRIEF

Ultrasonic Temperature Measuring Device



The problem:

One of the more important measurements required in nuclear rocket engine technology is the measurement of temperature in the core of the engine. This measurement has proven to be extremely difficult because of the high temperatures involved (≈5000° R), because of compatibility problems with some of the materials involved (graphite and hydrogen) and because of the intense and sustained neutron and gamma fluxes. Additional difficulties stem from the high ambient noise, shock, and vibration levels encountered in some locations, the high degree of accuracy and the response time required, possibility of temperature overshoot, high pressure, accessibility, geometrical restrictions, etc.

The solution:

A pulse echo ultrasonic system which automatically determines temperature by measuring the transit time of an acoustic pulse in a wire sensor. The measurement is based on the fact that the speed of sound in the sensor material is a function of temperature.

How it's done:

The principle elements of the ultrasonic system, shown in the figure include a transducer, a lead-in wire, a sensor, and an automatic electronic instrument for producing pulses and measuring the transit time between the two reflected pulses. A pulse is produced electrically in the transmitting coil T. This pulse is converted magnetostrictively to an acoustic pulse which travels down the lead-in wire to the sensor.

(continued overleaf)

The pulse is partially reflected from that point of the wire sensor where the acoustic impedance is changed. The acoustical impedance change in the sensor can be a kink, bend, or abrupt diameter change. The remainder of the pulse continues along the sensor and is reflected from the end of the sensor. The two reflected pulses travel back up the lead-in wire to the receiving coil R where they are converted in an inverse magnetostrictive manner to electrical pulses. The time between the two pulses is inversely proportional to the speed of sound in the sensor which is a function of sensor temperature.

The magnetostrictive transducer is made by winding a coil on a nickel alloy wire. In axially-magnetized wires, an extensional wave is propagated in the wire.

This device averages 10 measurements of transit time in the sensor to ±0.1 μsec., and provides this average reading in digital and analog form with an instrument response time of 0.1 sec.

Notes:

1. The ultrasonic thermometer offers several advantages over thermocouples, depending upon the application. These advantages are due partly to the greater choice of ultrasonic sensor materials. Only one material is required for the sensor instead of two as is required by a thermocouple. The ultrasonic thermometer does not require electrical insulation, thereby eliminating the shunting errors experienced by small thermocouples at high temperatures. The sensor may be installed bare in electrically conducting media if the sensor material is compatible with the environment. If a pressure seal is required, the lead-in wire can be brazed or welded to a sealing diaphragm which is thin compared to wavelength. Electrical feedthroughs or compression seals can also be used if compatible with the environment. The ultrasonic sensor, composed of only one material, is not subject to calibration shifts which, in thermocouples, are caused by diffusion of material from one leg into the other.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B68-10319

Patent status:

No patent action is contemplated by NASA.

Source: L. C. Lynnworth and E. H. Carnevale
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